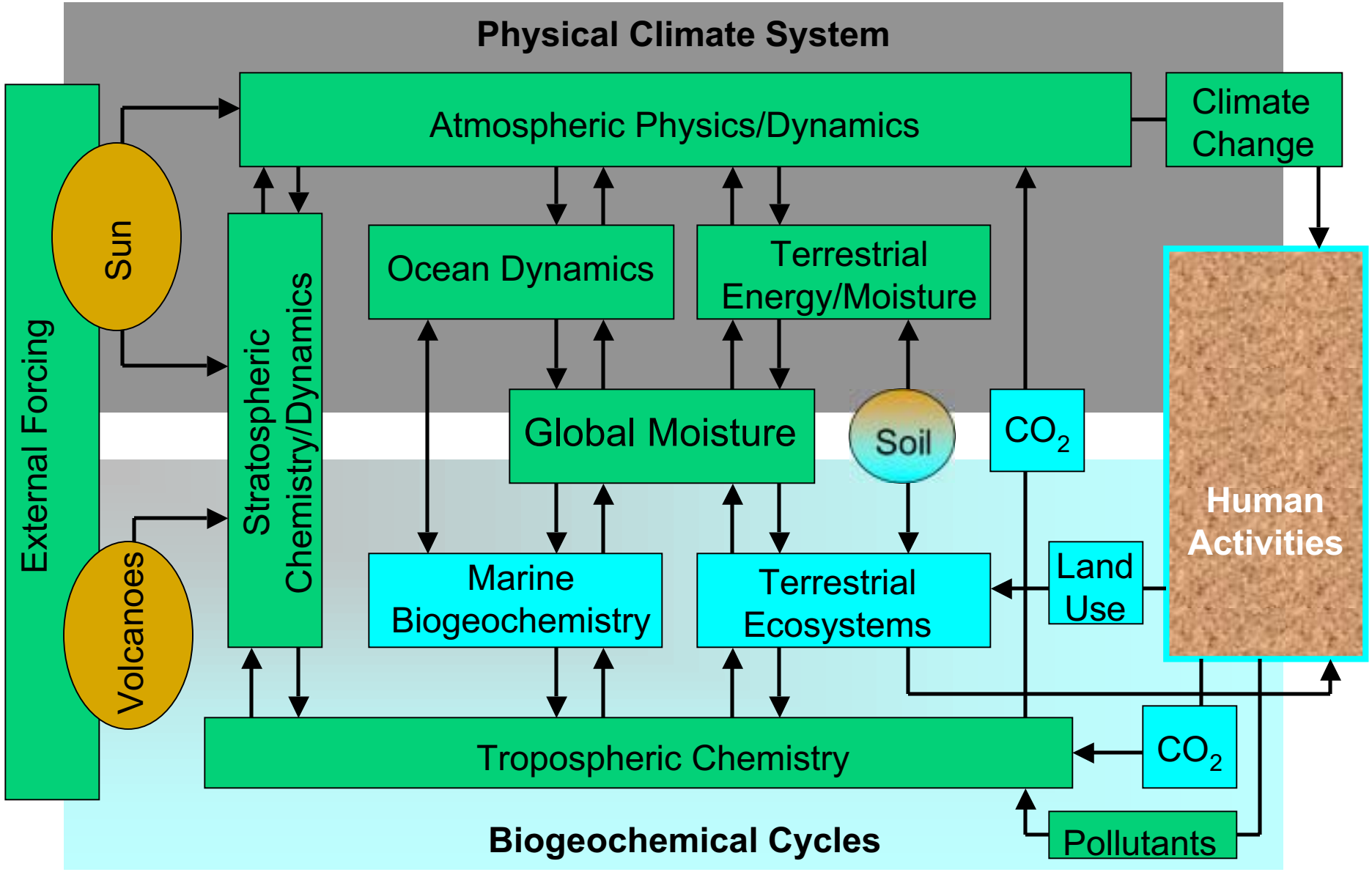
Linkages within ESE Research Program (examples)

Carbon Cycle & Ecosystems	CV&C	W	AC	WC	ES&I
Atm. CO_2 & CH_4 meas.			X		
Freeze/thaw for Carbon				X	
Soil Moisture & Wetlands				X	
Climate & Hydrology Data	X	X		X	
Ocean Circulation Models	X				
Salinity & Sea Winds	X				
Surface Topo. & Structure	X				X
Atm. Transport & Inversion			X		
Coupled Land-Atm. Models	X			X	
Shared field study resources	X	X	X	X	X
Earth System Modeling	X	X	X	X	X

Fluid and Biological Earth Processes
(from Earth System Science Report, 1986)



Needed Inputs, Outputs, and Outcomes

From Data and Information Systems and Services:

- Stable, efficient, timely, and affordable archive and distribution of climate data records, exploratory data sets, and comprehensive field campaign data sets
- Community-vetted process for identifying climate-quality data products and determining requirements, processing needs, etc. (e.g., community consensus algorithms and needs/activities for re-processing)
- Tools, services, and documentation that facilitate data access and analysis (handling large volumes of data, data mining; dealing with disparate formats, time and space sampling, sharing of expertise)

From Technology and Applications:

- Collaborations/partnerships that find ways to bridge gaps in the end-to-end process of developing a new capability to turning it over to an end user

Challenges for Carbon Cycle & Ecosystems: Gaps, Critical Path Issues, etc.

• Demonstrating we can secure the Climate Data Records for the next decade or two (both in terms of obtaining the data sets beyond the lifetime of the current satellites and of creating well-understood intercomparable time series data products) ➔ *Pathfinder "gap" has been painful; community is not uniformly optimistic about procurement strategies for future data . . .)*

• Investing in technology development and scientific preparedness for new measurements/science such that probability of success is maximized *(and frustrations minimized)*; how to be well positioned to make choices as science and technological feasibility advance

•Near-term challenge to conduct field campaigns / satellite validation while developing advanced platforms (and sensors?) ➔ *can we find commercial or other government platforms/sensors to meet our needs; can we do without, given we have more satellite capabilities; can we help accelerate something?*

Challenges for Carbon Cycle & Ecosystems: Gaps, Critical Path Issues, etc.

• Assuring the data and information systems and services in the future will be adequate to our needs ➔ *can we afford all that we need (LBA, NACP, SIMBIOS, high resolution land cover), will there be new gaps, what about changing data policies/pricing and commercial and foreign providers?*

• Assessing NASA's role in contributing to biodiversity and conservation science and related species, population, and community ecology issues (there are important global change issues here and a role for remote sensing and information science, but we haven't yet decided our approach)

• Developing a research emphasis to address consequences in coastal regions and to prepare scientifically (improved models, *in situ* validation, etc.) for OCO with level R & A funding

• Communicating and coordinating effectively across all the interfaces we must maintain: within ESE, with other U.S. government agencies, with the scientific community, with our international partners, with stakeholders, with the public, etc. ➔ *this is a people issue, but it is not just numbers, it is also a matter of having appropriate mechanisms and processes in place*

Strategic Planning

- **New ESE Research Plan**
- **Future Needs**

Earth Science Enterprise Research Plan Update

March 16, 2004

Bill Emanuel
NASA Office of Earth Science

Research Plan Update

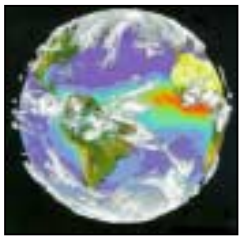
- Updating December, 2000 Research Strategy to serve as a research plan within the updated Enterprise strategy framework.
- Incorporating science focus areas as the primary organization for Enterprise research.
- Embracing the U.S. Climate Change Science Program (CCSP) and Climate Change Technology Program (CCTP) strategic plans.
- Addressing the evolving challenges of the Earth observations agenda.

ESE Strategy Documents

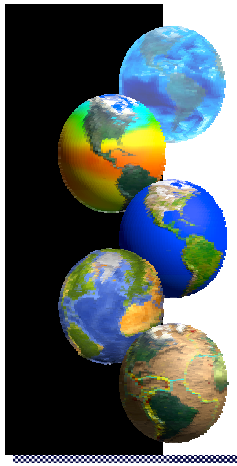
ESE Strategy

ESE Strategy

Research Plan

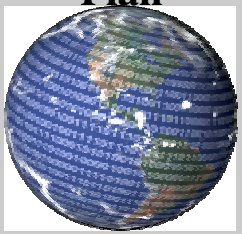


- *Observing approach*
- *Computational modeling approach*



Technology Plan

Data & Information Management Plan



Applications Plan

Education Plan

Research Plan Revision Process

- September 30, 2003: Draft circulated for comments.
- January 22, 2004: Review and comments by NASA center representatives provided recommendations for document reorganization.
- February 26–27, 2004: Workshop with NASA center representatives.
- April–May, 2004: Draft for formal reviews and community comment.
- NRC review pending timeline discussions.
- June–July, 2004: Final revisions.

Revised Research Plan Outline

1. Introduction
   - NASA and Enterprise vision and missions
   - Scientific rationale, Earth system concepts and change
   - Intention of the Research Plan
2. Approach to Earth System Science
   - Hierarchy of science questions
   - Science focus areas and road maps
   - Observations
   - Modeling, analysis, and predictions
3. Resources
   - NASA centers, University participation
   - Data systems, high-performance computing
4. Implementation
   - Criteria and process for evaluating priorities
   - Program metrics and evaluation
   - Community participation in program planning
5. Relationships to Other Programs
   - U.S. Climate Change Research Program
   - International (IGBP, IPCC)

Needs for Planning and More Planning . . .

Carbon Cycle and Ecosystems Focus Area

•Plan for Focus Area Review (FAR) on July 22, 2004
•Update Roadmap (needed by early fall, changes to be discussed at FAR)
•Advance Planning for next update of Research Strategy, ~2 years from now

"Land" Component of Focus Area (Roughly Terrestrial Ecology + LCLUC+ a small bit of Terrestrial Hydrology Programs)

•Define and Implement "Measurement-Oriented" Science Teams (measurements: vegetation indices, vegetation biophysical properties, land cover, fire, surface temperature)
•Identify and Define our "land" Climate Data Records (CDRs)

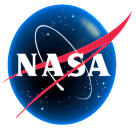
EOS/Terra/Aqua/MODIS, etc.

•Define a period peer review process for data products and new algorithms that can be used to inform NASA decision making on what products to produce, on what levels of support they should get, and on which should be archived for the long term

Needs for Planning and More Planning . . .

Terrestrial Ecology (TE) Program

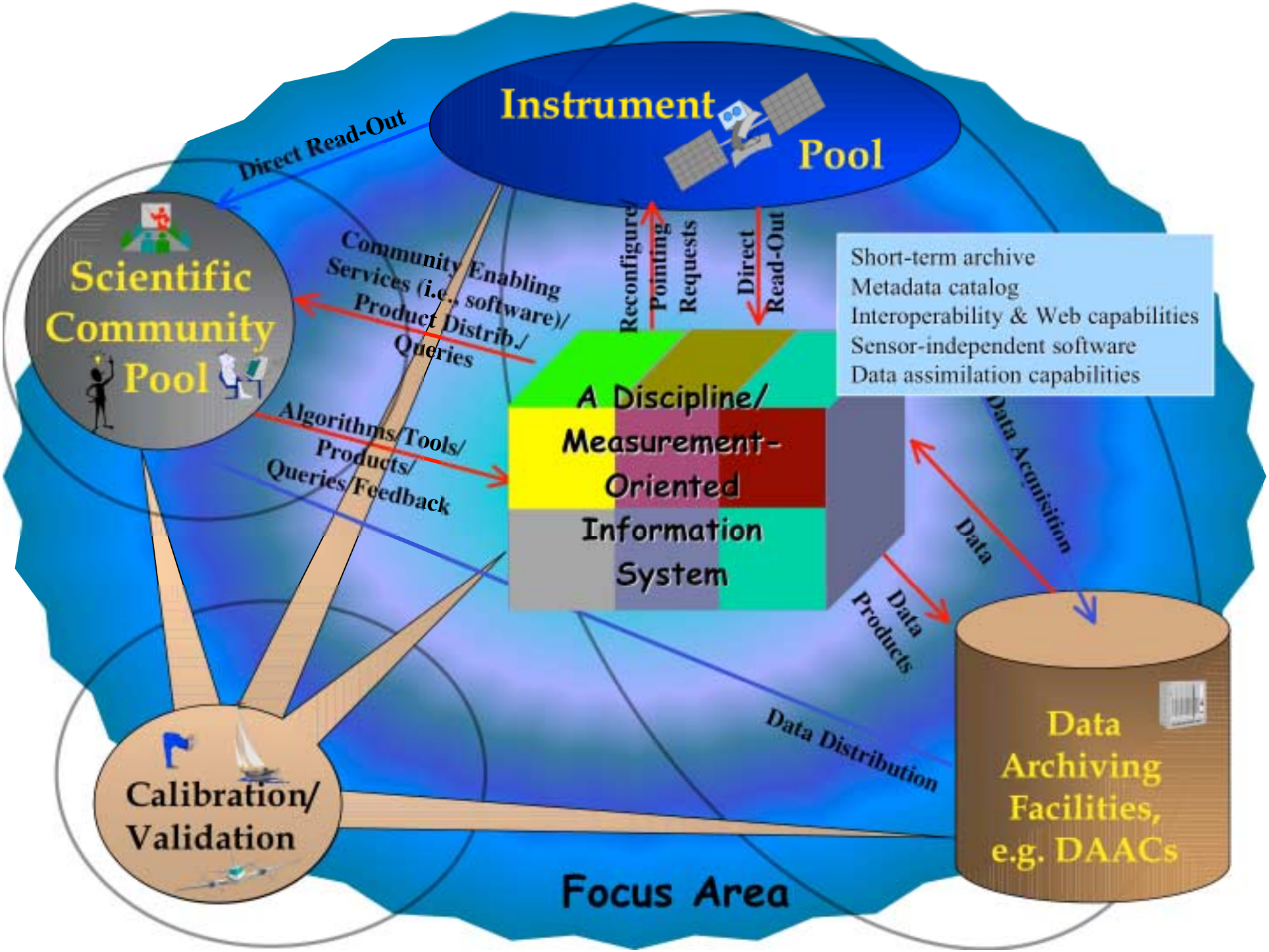
- Advance Planning for Terrestrial Ecology implementation (or should this be done with Focus Area?)
- Plan for implementation of NASA's TE contribution to the North American Carbon Program (NACP)
- Plan NASA's TE needs/future strategy for airborne platforms and sensors
- Plan for final synthesis and integration work under NASA's contribution to the Large Scale Biosphere-Atmosphere Experiment in Amazonia (LBA)
- Evaluate NASA TE needs for new "remote sensing science" (i,e., theory, development of new or advanced measurement and analysis methodologies)
- Initiate regular (~every 18 mo.?) science meeting for Terrestrial Ecology Program participants



Data and Computing

Challenges to NASA's Data Systems

- Enable flexibility within data systems to seamlessly adapt to new data stream(s) or to changes in current processing streams.
- Evolve from past instrument-focused processing systems to those that are measurement focused and can be distributed geographically and logically.
- Assure products flowing from processing stream meet the needs of the theme science teams - scientist working in conjunction with data systems experts, and in consultation with their communities.
- Identify and create interfaces that facilitate the flow of data to modeling efforts (e.g. carbon assimilation) - "one size does not fit all,,. Recognize the necessity for creating hooks into data mining and high performance computing environments.
- Create *measurement* oriented data systems within the SEEDS framework that will help guide the flow of information and services and improve performance and access.


Instrument Pool
Direct Read-Out
Scientific Community Pool
Community Enabling Services (i.e., software)/ Product Distrib./ Queries
Reconfigure
Pointing Requests
Direct Read-Out
Short-term archive
Metadata catalog
Interoperability & Web capabilities
Sensor-independent software
Data assimilation capabilities
Algorithms/Tools/ Products/ Queries/Feedback
A Discipline/ Measurement-Oriented Information System
Data Acquisition
Data
Data Products
Data Distribution
Calibration/ Validation
Data Archiving Facilities, e.g. DAACs
Focus Area

Summary of Near Term Data System Issues

- Missions to Measurements will require data systems to support data coming from multiple missions and instruments. The emerging data systems should be capable of rapidly adapting to rolling waves of capabilities derived from new instruments and measurements.
- Encourage discipline/measurement focused science communities to engage and develop consensus views on important data and data system issues - community adoption and buy-in (algorithms, selection of products, sharing expertise, etc). The Ocean Color Research Team demonstrates the value in the community approach.
- SEEDS activities in support of data system evolution will produce new opportunities to share and exchange solutions across communities. Information sharing from among theme communities will assure that data system solutions from one theme area can inform and possibly be adopted by others, including applications.
- The next phase in the development of data systems will require increased functionality - data systems means more than data processing and storage.

Carbon Cycle & Ecosystems: Current Data & Information Systems & Services Activities

DAACs:

GSFC – global, ocean, atmosphere

EDC - land

ORNL – biogeochemistry, field campaigns, land validation

ESIPs/REASoN:

TRFIC, Michigan State U.

GLCF, U. Maryland

AVHRR/MODIS/VIIRS Continuity

ISLSCP II Data

Project and Field Campaign:

SeaWiFS/SIMBIOS

LBA DIS

Carbon Cycle & Ecosystems: Computing

- Satellite data processing and requirements for high-resolution global data products (land cover, in particular) are putting intense demands on current systems: enhanced capacity, improved software/algorithms, and more automated processing approaches are need if we are to maintain and advance
- Present-day computational needs for modeling are largely being met with existing capabilities (from PI workstations to national computer centers)
- Anticipate requirements for carbon data assimilation will lead to additional demands on computational capacity – looks like ocean biological-physical carbon modelers will be making these demands first . . .

Public Outreach, Training & Education

ESE Outreach and Communication Strategy Goals

(Source: Draft ESE Outreach Plan):

•Promote Earth Science literacy to the public and convey the importance and uniqueness of ESE activities to science understanding, societal applications, and technology advancement

•Enable effective communication strategies and capabilities

•Support development of applications for use by stakeholders and decision-makers
•Empower internal and external intermediaries
•Help map Agency performance and products to plans.

•Public (e.g."government to citizen")

•Stakeholder (e.g. "government to government, policymakers")

•Intermediaries (e.g. "government to media, businesses, or value-add institutions

Note: Many Outreach Activities will overlap with Informal Education activities under the auspices of Code N-Education Enterprise

Carbon Cycle and Ecosystems: Example Outreach Activities

•"**Monitoring the Earth from Space With SeaWiFS**-An Online Presentation about Ocean Color

•**Living Ocean Teacher's Guide**-Curriculum and Activities on Ocean Color (available at http://seawifs.gsfc.nasa.gov)

•**The Colors of Life**-A Set of Stories and Animations about SeaWiFS and the Carbon Cycle

•**"From the Top of The World to the Bottom of the Food Web"-**Bigelow Laboratory's Online Resources on phytoplankton, algal blooms, satellites, etc. (http://www.bigelow.org)

•**SeaWiFS Globe Design Tool**-Allows for development of Global Data Sets from SeaWiFS for various outreach applications

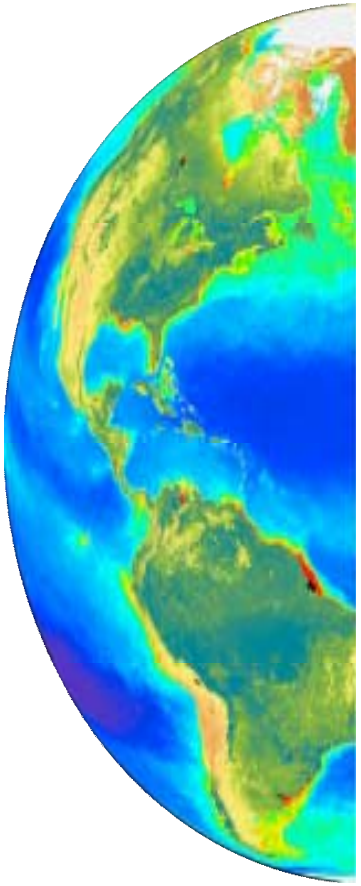
•**Program Scientists** serving as Host Researchers for the JASON Project

•Publishing the "Proceedings from the Symposium on Conservation Biology and NASA: New Opportunities for Research and Applications" and "Proceedings from the Workshop on Applications of NASA Technology for Biodiversity Conservation"

•Publishing of the **"Pipeline"-**An online newsletter for the NASA Oceanography community (http://oceans.nasa.gov)

•Online **databases** of programs, investigators, and topics in NASA Oceanography, Land Use/Land Cover

•Numerous press releases on global change and cycling of NPP and "Earth Breathing" as Carbon Cycle processes are elucidate with SeaWiFS, etc.



Education and training

•The Government of Brazil has emphasized the importance of training from the beginning of the program.

•The enhancement of research capacities and networks within Amazonia will advance global change science and applied research on regional issues.

•Training and education activities emphasizing post-doctoral, Ph.D., and Masters programs will strengthen the research community in Amazonia.

•LBA will train at least 100 new Ph.D.'s in Brazil. Over 500 Brazilian students have been involved. Brazil's Federal Government alone contributed R$2M to scholarships

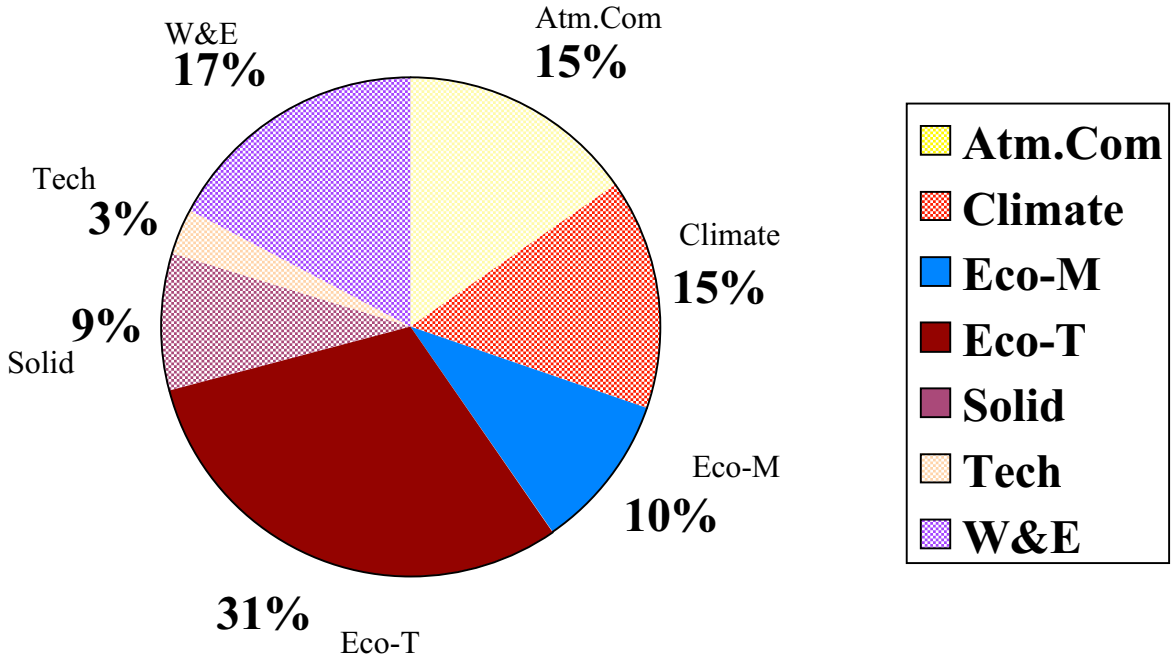
Public Outreach:

•Maintaining good relations with local communities is hard work but it is also a requirement for a successful field campaign.

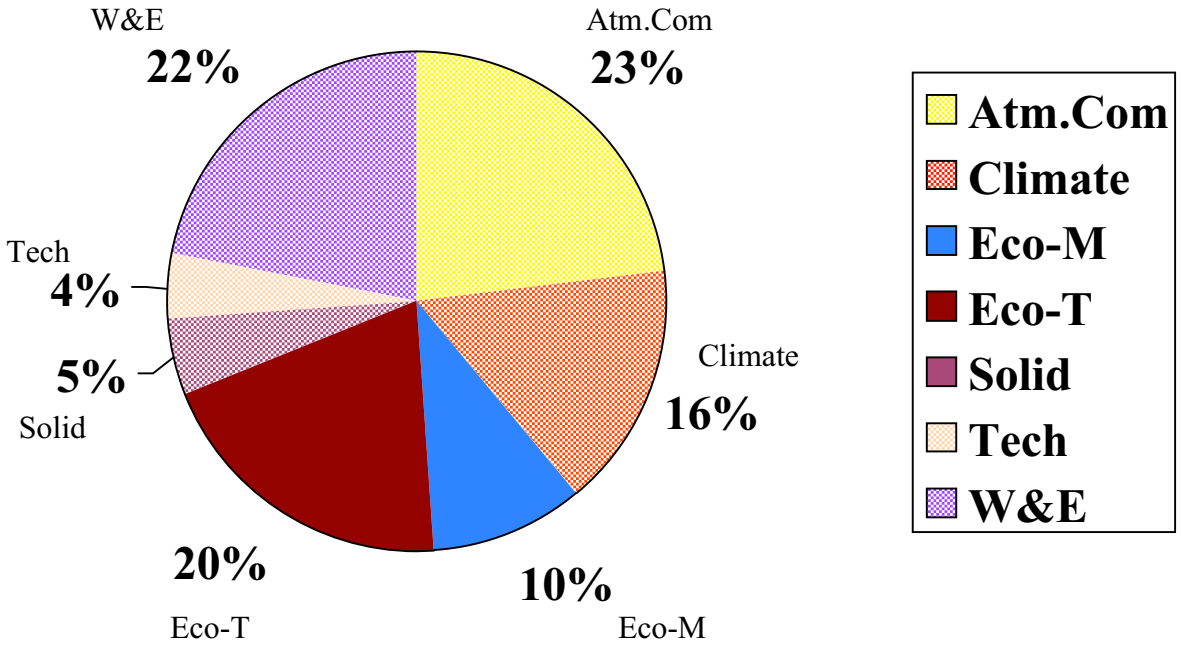
•Interactions with local communities strengthens our research and deepens our knowledge of the reality of the frontier.

•Involvement with the local communities provides a direct route between research results and applications.

Earth System Science Fellowships (2000-02)



New Investigators in Earth Science (1995-2002)



EPSCoR Program

Code N investment ~$10M/year

- 11 out of 35 awards are in Earth Science
- 3+2 years, beginning in 2001

Carbon/Eco/Bio grants have gone to:

Kansas State University-
Hyspire: Hyper-Resolution Remote Sensing of Rural Kansas; D. Goodin
Louisiana Universities Marine Consortium-
Optical Properties of the Northern Gulf of Mexico; M. Dagg
University of New England-
Viral Control of Coccolithophore Blooms in the Gulf of Main; J. Vaughn
University of Nebraska-Lincoln-
Airborne Remote Sensing for Agricultural Research; R. Narayanan
South Dakota School of Mines-
LAI for Fire Chronosequences of the Black hills and Southern Siberia; L. Vierling

Minority University Research Centers

Code N investment ~ $20M/year

- 6 of 20+ awards are in Earth Science
- 5+5 years, beginning in 1992

Carbon/Eco/Bio grants have gone to:

Southern University-

Center for Coastal Zone Assessment and Remote Sensing; M. Stubblefield

University of Puerto Rico-

Tropical Center for Earth and Space Studies; R. Fernandez-Sein

Interagency Relationships under U.S. Climate Change Science Program (CCSP)

NASA Focus Areas — CCSP Research Elements

NASA	CCSP
Climate Variability & Change	Climate Variability & Change
Weather	Atmospheric Composition
Atmospheric Composition	Land Use / Land Cover Change
Carbon Cycle & Ecosystems	Global Carbon Cycle
Water & Energy Cycle	Ecosystems
Earth Surface & Interior	Global Water Cycle
	Human Contributions & Responses

CCSP Carbon Cycle Science Questions

- What are the magnitudes and distributions of North American carbon sources and sinks on seasonal to centennial time scales, and what are the processes controlling their dynamics?
- What are the magnitudes and distributions of ocean carbon sources and sinks on seasonal to centennial time scales, and what are the processes controlling their dynamics?
- What are the effects on carbon sources and sinks of past, present, and future land-use change and resource management practices at local, regional, and global scales?
- How do global terrestrial, oceanic, and atmospheric carbon sources and sinks change on seasonal to centennial time scales, and how can this knowledge be integrated to quantify and explain annual global carbon budgets?
- What will be the future atmospheric concentrations of carbon dioxide, methane, and other carbon-containing greenhouse gases, and how will terrestrial and marine carbon sources and sinks change in the future?
- How will the Earth system, and its different components, respond to various options for managing carbon in the environment, and what scientific information is needed for evaluating these options?

CCSP Ecosystems Science Questions

•What are the most important linkages and feedbacks between ecological systems and global change (especially climate), and what are their quantitative relationships?

•What are the potential consequences of global change for ecological systems?

•What are the options for sustaining and improving ecological systems and related goods and services, given projected global changes?

CCSP Land Cover / Use Change Questions

•What tools or methods are needed to better characterize historic and current land-use and land-cover attributes and dynamics?

•What are the primary drivers of land-use and land-cover change?

•What will land-use and land-cover patterns and characteristics be 5 to 50 years into the future?

•How do climate change and variability affect land use and land cover, and what are the potential feedbacks of changes in land use and land cover on climate?

•What are the environmental, social, economic, and human health consequences of current and potential land-use and land-cover change over the next 5 to 50 years?

Carbon Critical Agency Dependencies For Carbon

USDA
- Forest & soil inventories
- Agricultural & forest managemt.
- Carbon sequestration

NOAA
- Meteorological observations
- Ocean surface temperature and land cover observations
- Atm. CO_2 flask/tall tower network
- Weather models (NCEP)
- Air-Sea CO_2 exchange studies
- Integrated carbon modeling
- Ship-based ocean CO_2 surveys

DOE
- Fossil fuel emissions
- AmeriFlux
- FACE and other CO_2 expts.
- Carbon databases (CDIAC)
- Carbon modeling
- Carbon sequestration

USGS
- Landsat data & data products
- Topography & land cover maps
- Stream gauge network

NASA
- Remote sensing: satellite time series (Landsat, SeaWiFS and EOS); expt. airborne sensors
- Remote sensing research
- Field campaigns--SAFARI, LBA
- Ocean, land, atmosphere and coupled carbon-climate modeling;
- Data sets & DISS

NSF
- Fundamental Earth science research
- Ocean field campaigns
- Process studies
- NCAR, NCEAS, LTER

\+ **NIST and ONR**

Interagency Linkages: Ecosystems

USDA
- Forest fire management
- Agricultural & forest managemt.
- Ecological Forecasting
- Multiple factor experiments

NOAA
- Meteorological observations
- Ocean and land observations
- Weather models (NCEP)
- Ship-based ocean surveys
- Ecological Forecasting

DOE
- AmeriFlux process studies
- Multiple factor manipulative experiments (e.g., FACE)
- Ecosystem modeling & Ecological Forecasting

USAID
- Famine Early Warning

Smithsonian Institution
- Ecological Forecasting

USGS
- Landsat data & data products
- Topography & land cover maps
- Invasive species management
- Ecological Forecasting

NSF
- Fundamental research
- Ocean field campaigns
- Process studies
- NCEAS, LTER
- Ecosystem Modeling & Ecological Forecasting

ONR
- Ocean field campaigns
- Coastal studies

EPA
- Ecological Forecasting

NASA Participation in (CENR) Subcommittee on Ecological Systems (SES)

Desired Outcomes:

• **Scientific assessments** of specific ecosystem responses to potential environmental changes and quantitative carbon budgets and emissions estimates of key global ecosystems for decision-making purposes

• **Fundamental understanding** of primary productivity and the consequences of land cover and land use change as a basis for applications to agriculture, forestry, fisheries, sustainable land and marine resource management, **carbon management**, and biodiversity conservation

• **Information on ecosystem interactions** with the atmosphere that can be used to improve weather and climate prediction and to assess impacts on atmospheric chemistry